on the Ceylon pearl oyster. These dealt with (1) the kind of ground on which the oysters live and the objects to which they are attached; (2) the oyster-eating fishes and other enemies which affect the life of the oyster; and (3) the different types of oyster and the question of their constancy.

Dr. A. Smith Woodward gave a lecture on the evolution of fishes. Prof. R. J. Anderson gave details respecting (1) the epiphyses of long bones, chiefly in sauropsids, and (2) measurements of the maxilla in Mammalia. Prof. Alexander Fraser directed attention to some points connected with the alimentary canal of the higher mammals, and Dr. H. E. Roaf gave a summary of his experiments on the physiological action of the digestive enzymes of certain invertebrates, but these communications cannot be summarised in the space here available.

J. H. ASHWORTH.

ENGINEERING AT THE BRITISH ASSOCIATION.

THE president of the section of engineering, Mr. Dugald Clerk, is so well known for his researches on the gas engine, and has done so much to place the theory of gas-engine work upon a true scientific basis, that it was only to be expected that the work of Section G should be largely concerned with gas-engine practice and allied industries. The president in his address gave an instructive and valuable summary of the early history of the study of thermodynamics, and of the application of its principles to engine design.

After the presidential address on Thursday, September 3, only one paper was dealt with, that by Mr. G. Stoney, on recent developments in steam turbines. At the York meeting in 1906 Mr. Stoney read a paper on the same subject, and the present paper, which was a continuation of the former, showed conclusively how rapid the progress had been during the past two years. The author first dealt with the changes in the design of continuous-current dynamos to adapt them to the high speed of the turbine, and stated that now as much as 1500 kw. was put into a single armature. In turbo-blowers for blast-furnace work there had been a great advance; a blower to deliver 20,000 cubic feet of air per minute only weighed 25 tons, against 450 tons for the ordinary reciprocating engine of the same capacity. The use of the exhaust steam from non-condensing reciprocating steam engines in turbines, which took in their steam at atmospheric pressure and exhausted it into condensers, was then dealt with, and such refinements as mixed-pressure turbines, where a high-pressure turbine using boiler steam comes automatically into action when the low-pressure steam supply fails. Improvements in condensers to increase the available vacuum—such a very important matter in turbine economy—were then touched upon, and, finally, the wonderful advance in the application of the turbine to marine work was briefly discussed—in eight years the horse-power so utilised had increased from 25,000 to 1,750,000.

Friday, September 4, was entirely devoted to a joint discussion with Sections A and B of the first report presented by the committee of the section on gaseous explosions, which was appointed at the Leicester meeting in 1907. This report not only summarised in a convenient form for reference what was known up to the present time on the subject, but also described the experimental work which had been carried out by various members of the committee. While Boyle's law might be considered holding under all the conditions met with in gaseous explosions in the gas engine, it had long been realised that it was probable that the law $PV=kT$ did not hold at the high temperatures reached in such explosions. The experimental work on this question was divided in the report into three classes:—(*a*) constant-pressure experiments; (*b*) constant-volume experiments; and (*c*) experiments in which both volume and pressure were varied; those carried out by Mr. Dugald Clerk fell into this last class. The results obtained by the various experimenters were fully discussed in the report, and from data obtained from several of the best-known experiments curves were drawn showing the relation between the temperature in degrees centigrade and the energy in calories per gram molecule. As a result of its investigations the committee had prepared a table giving the energy at four different temperatures in calories per gram molecule of air, CO_2, H_2O, gas-engine mixture, and ideal gas, and curves were drawn for the gas-engine mixture and the ideal gas. In the form of an appendix to the report was a valuable note, by Prof. H. L. Callendar, on the deviation of actual gases from the ideal state, and on experimental errors in the determination of their specific heats. Prof. Callendar showed that there was a possible systematic error inseparable from experiments made by Regnault's methods, due to the fact that the correction required for the flow of heat by conduction from the heater to the calorimeter had to be based upon experiments made with no gas passing. A long and interesting discussion took place, the chief speakers being Dr. Harker, Prof. Harold Dixon, who has done such excellent work in the determination of the specific heats of gases at high temperatures, Prof. Dalby, Prof. Coker, who described the method by which he had determined the fluctuation of temperature on the inner surface of the cylinder wall of a gas engine, and Prof. Bernard Hopkinson, who stated that in his experimental work he had discovered that the gases at the moment of combustion were able to radiate a considerable quantity of heat. The discussion was closed by the president of Section G, who expressed the view that the experimental work which is now being carried out by Prof. Callendar and Prof. Dalby, which was referred to by the latter gentleman in the discussion, would be of very great importance. Prof. Callendar and Prof. Dalby in their experiments on the determination of temperatures inside gas-engine cylinders used an extremely fine platinum wire, and withdrew it from the cylinder during the time the temperature was at its maximum, and, as a result of their work, they believed they had obtained temperatures accurate to within 1° C.; if the temperature is known accurately at one point of the indicator card, it could certainly be calculated for other points.

On Monday, September 7, the first three papers were devoted to peat and producer gas. Captain Sankey read the first paper, on the utilisation of peat for the making of gas or charcoal. He stated that the subject was one of great importance to Ireland, and was of interest in view of the fact that a Bill had been passed by Parliament sanctioning works to produce gas from peat, and to use this gas for making electricity by means of gas engines and dynamos, and to distribute the power thus generated to works which would be established in the neighbourhood of the power station. The Bill had given power to utilise a portion of the bog of Allan, near Robertstown, on the Grand Canal, about twenty-five miles from Dublin. Earlier attempts to utilise peat had failed, because they were based on the use of dry peat, that is, peat containing 25 per cent. of water, and the cost of such drying and of converting the dry material into briquettes was too great to allow it to compete with coal, and, further, there was no recovery of by-products. The proposed scheme proceeded on different lines; the peat would only be partially dried, that is, to about 60 per cent., and it would then be used in producers for generating gas, and the by-products would be recovered. It was hoped that the profits on these would cover the cost of procuring and drying the peat. Great progress had been made in Germany in the utilisation of peat, and the author described several plants he had seen at work. The peat could be obtained by four different methods:—by hand labour entirely, by cutting by hand and then shovelling it into an elevator, or by digging it and spreading it for drying by a machine, or, finally, the peat could be dug by means of an ordinary grab, which was the method adopted at Schelecken, in Prussia. Probably the grab method would be the best for the proposed power scheme, and the drying might be carried out by means of Dornberg presses. The principal by-product in the manufacture of peat gas is sulphate of ammonia, and the proposed power station would probably be able to produce about 3000 tons per annum. Other important by-products are acetate of lime, methyl alcohol, and tar; an excellent waggon grease can be made from this tar. The author estimated that the monetary value of these

additional by-products would be equal to that of the sulphate of ammonia, and he stated that a good charcoal could be made direct from peat and the by-products recovered, and that a satisfactory process had been in operation in Oldenberg for more than ten years.

The second paper, on producer gas, by Mr. Emerson Dowson, was noteworthy from the fact that the first paper on this subject by the author was read at the York meeting in 1881; the present paper contained a summary of the progress which had been made during the last quarter of a century. In concluding his paper, Mr. Dowson dealt briefly with the two types of producers now utilised for engine work. The suction plant cost less and occupied less ground space, but the gas made in it was not so strong as in the older form of pressure plant—in some cases this advantage of the latter is important. He stated that the fuel consumption per horse-power hour and the labour required were about the same in both types of plant, provided the steam required was raised by means of an independent boiler.

The third paper, by Mr. Robson, was entitled "The Production of Cheap Power by Suction Gas Plants." The author stated that the figures he was able to produce showed that the modern gas engine and suction producer could give power to small users and to large users more cheaply than could be obtained by any other process. In the form of a table he gave three typical examples, one, where the installation was 450 B.H.P., the total cost per B.H.P. hour, allowing for depreciation and interest on capital, worked out at 0·205*d*., and where the size of the installation was only 20 B.H.P. the cost was 0·745*d*. Up to the present suction producers had been made to work on a commercial scale only with non-bituminous fuels, and fortunately such fuels were easily obtainable in the industrial centres of this kingdom. The tar difficulty had been the chief trouble in making a successful suction producer work with bituminous fuels, as the apparatus required for the cleaning of the gas both increased the frictional resistance of the passage of the gas from the generator to the engine and destroyed the simplicity of the arrangement. The author discussed several methods by which this difficulty might, he considered, be overcome.

In the discussion on these papers, Mr. W. Crossley, the well-known gas-engine maker, gave some interesting figures his firm had obtained as the result of experiments they had been carrying out on the utilisation of peat with a peat containing 2·2 per cent. of N; they estimated that a profit of 5*l*. 12*s*. per ton would be obtained from the sulphate of ammonia, and with 1·6 per cent. of N (about the average figure for Irish peat) the profit would still be 4*l*. 1*s*. per ton of sulphate of ammonia produced; this practically meant that the power which would be generated would cost nothing, and could, therefore, be retailed at a cost which would ensure the establishment of industries requiring a large amount of power at a low cost.

The concluding paper for the day was by Mr. W. Rosenhain, on the study of breakages. The author, after emphasising the need of a careful study of every case of breakage, if engineers were to obtain information which would enable them to prevent the recurrence of such breakages, stated that the causes of failure might be classed into three different groups:—(1) those due to defects arising from the manufacture of the material of construction; (2) those arising from incorrect treatment of the material during the process of construction; and (3) those from defects arising during the life of the structure or machine. Mr. Rosenhain illustrated these three cases by examples selected from investigations which had been carried out at the National Physical Laboratory. The first case was that in which the inner tube of a large gun had failed by internal cracks, and the microscopic and mechanical tests showed that the failure was probably due to a defect in the original steel ingot, viz. to its contamination to an undue extent with enclosures of slag. The second case was a fractured locomotive crank pin; here the microscopic investigation pointed to the conclusion that a material of an originally satisfactory character had been spoiled by a too severe hardening process; this example was a direct testimony to the value of microscopic observations in giving a clue to the thermal history of a specimen of steel. The third case was a broken shaft, where the investigation showed that the coarse structure of the material in the central portion of the cross-section of the shaft, which was undoubtedly the cause of the fracture, had been present in the steel as supplied by the manufacturer, and could not have been produced as the result of vibration or working stresses. Mr. Rosenhain's paper was an extremely valuable one, and indicated the good work which is being and can be carried out in such an institution as the National Physical Laboratory.

A paper by Prof. E. Wilson, describing his further experiments on the electrical conductivity of light aluminium alloys as affected by exposure to London atmosphere, was taken as read.

The section opened its proceedings on Tuesday, September 8, with a paper by Mr. F. W. Lanchester on the laws of flight. The paper was illustrated by a number of interesting experiments with model aëroplanes. Mr. Lanchester has been working on the subject for a number of years, and has evolved mathematical expressions for the path which is followed by a ballasted aëroplane and for its stability; generally speaking, the path is undulating, and under certain conditions the aëroplane will describe complete loops in the air. The mathematical investigations into the stability of aëroplanes showed that the velocity of flight must be considerable when the machine was a large one, and therefore a large plane required more power per lb. of weight than a small one, thus limiting the weight of flying machines of the aëroplane type. Mr. Lanchester directed attention to the fact that there was not much to be gained from the study of the flight of birds, carried out in the haphazard fashion which had hitherto characterised such work; he pointed out, in particular, that it was only rarely that the observer had ever recorded the weight of the birds the flight of which he had been studying. In the course of the discussion Mr. Lanchester stated that, in his opinion, the engine problem would not be simplified in the case of large-sized aëroplanes, and he thought that the engines would require to be air-cooled; he had himself built a considerable number of such engines, which worked quite successfully. At the present time he was of opinion that the best results would be obtained with a machine weighing, with its driver, not more than half a ton.

The next paper was by Mr. F. A. Royce, on the causes of wear in motor vehicle machinery; the author dealt with his subject under three heads:—(*a*) design; (*b*) material and workmanship; (*c*) lubrication and attention. To illustrate his first point examples of defective designs in bearings were discussed and criticised, and in connection with lubrication the importance of devices for retaining the oil on parts subjected to friction, and of always maintaining a film of oil between the rubbing surfaces, was strongly emphasised.

The last paper of the day was one by Sir Howard Grubb, on clock-driving mechanisms for telescopes; for spectroscopic and photographic work with telescopes it was necessary that the clock-driving mechanism should not only drive the telescope at its normal rate, but also correct any errors of position which might occur and would accumulate. The problem—always a difficult one—had been solved most satisfactorily by the use of electrical control, and the author described the method adopted by him for the 24-inch equatorial at Oxford University; the mechanism is, briefly, epicyclic gearing, which is operated electrically, the necessary electrical contacts being controlled by a pendulum. In the discussion Dr. Rambaut, of Oxford University Observatory, stated that the delicacy of the adjustment obtained by this device was remarkable; the tube of the telescope was 22 feet 6 inches long, hence a second of arc was represented by a linear measurement of less than 1/100 millimetre, while in their photographic work they aspired to keep the position of the images true to 1/12,000 millimetre, and not only was the delicacy of the adjustment so perfect, but the simplicity was equally remarkable; it was quite unusual for any adjustments to be required.

Owing to the number of papers presented, the section sat again on the morning of Wednesday, September 9,

when three papers were read. The first, by Mr. J. Brown, F.R.S., and Prof. Maurice Fitzgerald, described a series of experiments they had carried out on rotating discs. The discs were rubber—one solid, 12 inches in diameter, with its thickness tapering from 2½ inches in the middle to ½ inch at the edge, and the second 12 inches in diameter, ⅜-inch thick at the edge, and 3 inches thick in the middle, where it was pierced with a 1½-inch hole. In the first disc the thickness varied uniformly from the centre to the edge; in the second the cross-section of the disc formed a hyperbolic curve. The object of these experiments was to determine, by measurement of the strains set up when the discs were rotating, whether the formulæ usually employed in the calculation of stresses in the revolving discs of steam turbines were reasonably trustworthy. The discs were carried at the lower end of a vertical shaft, which was driven at a high speed by an electric motor; photographs were taken of the revolving disc, and strain measurements were thus possible. As a result of their experiments, the authors were of opinion that the ordinary formulæ did not give results which were approximate enough for ordinary use. Of course it is well known that these formulæ are only approximate, but it is doubtful whether the experiments of the authors are sufficiently conclusive to prove that the formulæ are as untrustworthy as was suggested in the paper.

The next paper was by Mr. Douglas Fox, on general urban and interurban transportation and rail-less electric traction. This paper contained, in the form of tables, an exhaustive analysis of the costs, working expenses, receipts, &c., of some seventy-one tramway installations in the United Kingdom. The examples selected by the author embraced towns having combined generating stations for traction and electric lighting, and towns which had separate generating stations for their tramways and their lighting. Details were also given of several installations of electric road traction on the Continent, where overhead wires were employed and there were no rails; one of the latest of these was at Mulhausen, in Alsace, where it had been decided to adopt rail-less electric cars in order to connect up the suburbs with the existing electric tramways in the city proper. Mr. Fox was of opinion that in many of the municipal tramways ordinary business principles had been neglected and that the public had been allowed to travel at the expense of the ratepayer, fares being too low to allow, after working expenses had been defrayed, of the setting aside of a reasonable sum for depreciation and renewal.

The section concluded its proceedings with a paper on the strength of solid cylindrical, round-ended columns, by Prof. W. E. Lilly. In previous papers by this author the importance of secondary flexure and its influence on the strength of columns had been demonstrated, and as a result of his researches he had suggested the revision of the formula at present in use for the design of columns. The modified formula which the author had suggested required certain constants, and the object of the experiments described in the present paper was the determination of the value of these constants. Experiments had been carried out on columns of cast tool steel, Bessemer steel, mild steel, wrought-iron, and cast-iron, and the results obtained were given by the author in the form of a table; the constants in this table were for use with the well-known Rankine Gordon formula.

AGRICULTURE AT THE BRITISH ASSOCIATION.

THE Dublin meeting of the British Association was marked by the resuscitation of the subsection of agriculture, which, after a previous temporary existence as a dependent of botany and some fitful appearances as a branch of chemistry, now became associated with economics. As was appropriate in these circumstances, and with Sir Horace Plunkett as president, the work of the subsection was mainly concerned with the economic, or rather with the sociological, side of agriculture.

Thursday morning was occupied with the presidential address, in which, at the outset, Sir Horace said that he spoke neither as a man of science nor as a practical farmer, but as a man of affairs whose way of life had brought him into close touch with the conditions, human and material, which it will be the aim of the subsection to improve. His purpose was to establish the claim of agriculture to a new position in the domain of science, for reasons that are primarily neither scientific nor practical, but political. It does not appear to have been sufficiently considered how far the ethical and physical health of the modern city has been due to the constant influx of fresh blood from the country. At present the town makes an irresistible appeal to the spirit of enterprise, to the growing craving for excitement, to the desire to live where there is most life. But sooner or later, if the balance of trade in this human traffic be not adjusted, the raw material out of which urban society is made will be seriously deteriorated, and the national degeneracy will be properly charged to those who failed to foresee the evil and treat the cause. If the problem has not yet received the proper attention at the hands of the sciences, its urgency is growing in the public opinion and stirring the centres of government. The influence of the British Association upon national life must depend, not upon its highest achievements in the region of pure science, but upon the degree in which it establishes and maintains a mutually helpful relationship between science and productive effort. He did not suggest that agriculture had not shared in the benefits with which science, physical and social, had richly endowed the whole field of industrial effort, urban and rural. But there is surely a marked disparity between the attention given to urban and rural affairs by those engaged in the application of science to the advancement of mankind. A great gulf, no doubt, separates the agriculture of Vergil from that of Sir John Lawes, but how insignificant it is beside the ocean of knowledge which stretches between Archimedes and Lord Kelvin. In his work in Ireland he had been in the habit of employing a rough formula to indicate the three-fold character of the constructive work that is needed in rural life—*better farming*, *better business*, and *better living*. To each of these three divisions the sciences ought to be most helpful; the natural sciences to the first, economic science to the second and third, educational science to all three. Sir Horace then proceeded to emphasise in greater detail the necessary part played by research, by economic investigation, and by education in rural reconstruction. Lastly, he proceeded to plead for the more adequate recognition of agriculture by the association; he demanded that it should be accorded the dignity of a section instead of being left in its present unstable condition, without any organisation to secure the continuity of even a subsection from year to year. The association might thus help to "counteract tendencies through which preceding empires, after they had arrived at a stage very similar to that which we occupy to-day, hastened to their decline and fall. Be this as it may, it would hardly be an exaggeration to say that modern civilisation has joined the rural exodus. Let it be the high aim of the British Association, leading science and practice hand in hand, to call it back."

In the afternoon following the presidential address, Sir Oliver Lodge described some of the experiments, which are being made on a large scale near Worcester, on the effects of a high-tension electrical discharge over a growing crop. While carefully guarding himself from any speculation as to whether the seat of the action was in the soil or the plant, whether a stimulus action or an inflow of energy, there seemed to be a positive result which was quite outside the domain of experimental error. Mr. J. H. Priestley, who has been associated with the experiments, gave some further details, and explained the investigations he had in hand to elucidate the nature of the action of the electricity. Then followed a paper by Prof. J. R. Campbell, of the Irish Department of Agriculture, in which he lucidly explained the educational work of that department, where the following of a carefully considered policy has achieved much happier results than the wasteful English method of leaving each county council to go as it pleases. Education was also the text of the next paper, by Dr. Carroll Dunham, of Harvard, in which he compared the systems of agricultural education prevailing in the United States, according as their aim was to prepare